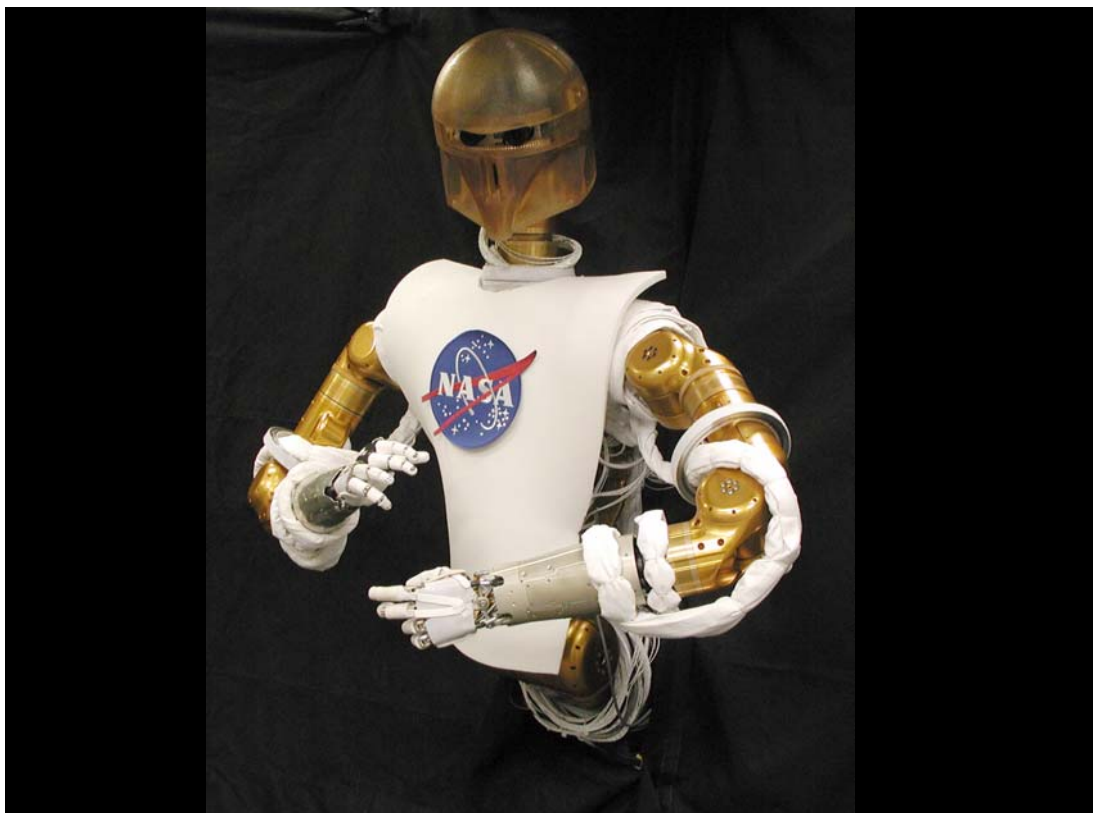




Spacebots

An Educator Guide



Spacebots

A Digital Learning Network Experience



Designed To Share

NASA's Space Exploration Program

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Digital Learning Network (DLN) Expedition

A DLN Expedition is a one time connection that allows students to experience NASA first-hand. Each expedition features an integrated educational package of grade-appropriate instruction and activities centered around a 50 minute videoconference. Students participate in a Question and Answer session with a NASA JSC education specialist or a NASA Subject Matter Expert.

SEQUENCE OF EVENTS

Pre-Conference Requirements

Online Pre-assessment A pre-assessment tool is available to determine the students' level of understanding prior to the videoconference. Suggested answers are included.

Expedition Videoconference

Expedition Videoconference (50 minute conference)

Robots have been a staple of our culture for the past half-century. We have all seen them in movies, on television, and in science fiction stories performing tasks that range from the mundane to the extraordinary. Because of the mental images we have of robots, sparked in great measure by the influence of science fiction, we often fail to recognize how widespread their use is in our daily lives. Everywhere we look, robots and automated systems do work for us and help make our lives more convenient if not easier. Often we do not recognize real robots because they differ from the images we have of them and from the jobs we tend to believe they do. As our society becomes more technologically dependent, however, the role of robots will increase significantly and knowing what they do and how they do it will be an important factor in many professions of the future. NASA already uses robotics technology to great extent in its exploration of space. During this Expedition, students and teachers will have an opportunity to learn firsthand about NASA's use of robots and how they are being designed and built to help humans explore the universe. Learn how NASA defines robotics, see how robotic systems are already widely used in the space program and what plans there are for future robotic applications. This interesting look into the world of space robotics will also highlight educational and professional opportunities that could be the catalyst that helps some students to identify a career path. So join us for this live, interactive learning session for a glimpse into the technologies of the 21st century happening now at NASA.

Post-Conference Requirements

Online Post-assessment

A post-assessment tool is available to determine changes in student levels of understanding.

NASA Education Evaluation Information System (NEEIS) Feedback Forms

Educator and student feedback forms are available online for all DLN events.



Expedition Overview

Grade Level(s) 9-12

Focus Question

How are robotics used in space exploration and what are some of the career opportunities that exist in the field of robotics?

Instructional Objectives (accomplished through videoconferencing and pre- and post-activities)

- Define the term “robot” historically and identify everyday applications.
- Discuss the characteristics of robots and their role-use in space exploration.
- Explore career opportunities and the education required in the field of robotics.

National Standards

Table Below

Texas Standards

Table Below



National Standards

****PLEASE NOTE:** Due to the longevity of standard descriptions, expected student behaviors are listed below as text. The standard is listed in the chart.

National Science Education Standards (NSES) (from www.nap.edu)

<i>Science</i>	Robotic Arm	Robotic Maze	Robot Hand
Content Standard E: Science and Technology Abilities of technological design	X	X	X
Content Standard G: History and Nature of Science Science as a human endeavor	X	X	X

Student Behaviors:

Content Standard E: Science and Technology

Abilities of Technological Design (9-12): Children in grades K-4 understand and can carry out design activities earlier than they can inquiry activities, but they cannot easily tell the difference between the two, nor is it important whether they can. In grades K-4, children should have a variety of educational experiences that involve science and technology, sometimes in the same activity and other times separately. When the activities are informal and open, such as building a balance and comparing the weight of objects on it, it is difficult to separate inquiry from technological design. At other times, the distinction might be clear to adults but not to children.

Content Standard G: History and Nature of Science

Science as a human endeavor (9-12): Teachers should be sensitive to the students' lack of knowledge and perspective on time, duration, and succession when it comes to historical study. High school students may have difficulties understanding the views of historical figures. For example, students may think of historical figures as inferior because they did not understand what we do today. This "Whiggish perspective" seems to hold for some students with regard to scientists whose theories have been displaced.

International Technology Education Association (ITEA) (from www.iteaconnect.org)

ITEA <i>Technology</i>	Robotic Arm	Robotic Maze	Robot Hand
Standard 8: Students will develop an understanding of the attributes of design. (9-12) The design needs to be continually checked and critiqued, and the ideas of the design must be redefined and improved.	X	X	X
Standard 9: Students will develop an understanding of engineering design. (9-12) Engineering design is influenced by personal characteristics, such as creativity, resourcefulness, and the ability to visualize and think abstractly.		X	

Student Behaviors:

Standard 8: As high school students develop a greater comprehension of the design process, they will have opportunities to explore the attributes of design in greater depth. The attributes of design include the following characteristics: the design is purposeful; it is based on specific requirements; it is systematic; it is iterative; it is creative; and there are many solutions to a design problem.

Standard 9: Students in grades 9-12 are introduced to two or more concepts in the engineering design process: making prototypes and using design principles. A prototype provides a means for testing and evaluating the design by making observations and necessary adjustments. Students are also introduced to design principles, such as balance, proportion, function, and flexibility.

National Council of Teachers of Mathematics (from www.nctm.org)

NCTM <i>Mathematics</i>	Robotic Arm	Robotic Maze	Robot Hand
Standard 21: Connections (K-12) a. Recognize and use connections among mathematical ideas. b. Understand how mathematical ideas interconnect and build on one another to produce a coherent whole. c. Recognize and apply mathematics in contexts outside of mathematics.	X	X	X
Standard 12: Understand measurable attributes of objects and the units, systems, and processes of measurement. (9-12) Make decisions about units and scales that are appropriate for problem situations involving measurement.	X	X	X



Texas Standards (TEKS)

Texas Essential Knowledge and Skills (TEKS)

All 9-12 pre-activities meet the following Texas standards:

Science

2) Scientific processes. The student uses scientific methods during field and laboratory investigations. The student is expected to:

- (A) plan and implement investigative procedures including asking questions, formulating testable hypotheses, and selecting equipment and technology;
- (B) collect data and make measurements with precision;
- (C) organize, analyze, evaluate, make inferences, and predict trends from data; and
- (D) communicate valid conclusions.

(3) Scientific processes. The student uses critical thinking and scientific problem solving to make informed decisions. The student is expected to:

- (A) analyze, review, and critique scientific explanations, including hypotheses and theories, as to their strengths and weaknesses using scientific evidence and information;
- (B) draw inferences based on data related to promotional materials for products and services;
- (C) evaluate the impact of research on scientific thought, society, and the environment;
- (D) describe connections between physics and chemistry, and future careers; and
- (E) research and describe the history of physics, chemistry, and contributions of scientists.

Social Studies

(23) Science, technology, and society. The student understands the influence of scientific discoveries and technological innovations on daily life in the United States. The student is expected to:

(A) analyze how scientific discoveries and technological innovations, including those in transportation and communication, have changed the standard of living in the United States; and

(B) explain how technological innovations in areas such as space exploration have led to other innovations that affect daily life and the standard of living.

English

(4) Writing/inquiry/research. The student uses writing as a tool for learning. The student is expected to:

(A) use writing to formulate questions, refine topics, and clarify ideas;

(B) use writing to discover, organize, and support what is known and what needs to be learned about a topic;

(C) compile information from primary and secondary sources in systematic ways using available technology;

(D) represent information in a variety of ways such as graphics, conceptual maps, and learning logs;

(E) use writing as a study tool to clarify and remember information;

(F) compile written ideas and representations into reports, summaries, or other formats and draw conclusions; and

(G) analyze strategies that writers in different fields use to compose.



A week before the event, students will need to take the online pre-conference assessment. This short assessment will provide useful background information for the presenters to prepare for the videoconference.

- Page 11

- 3) Write a set of directions on how to move your arm from your side to scratch your nose. This will be a set of program directions similar to those written by engineers working to design a robotic system for movement to complete a task.

4) Match the following terms with their correct definitions:

Articulated		A mechanical or electromechanical device that performs human tasks, automatically or by remote control.
End Effector		The study and application of robot technology.
Degrees of Freedom		Each plane in which a robot can maneuver.
Anthropomorphic		To move by turning over and over. To rock back and forth.
Dexterity		Jointed arm.
Yaw		To move left or right with out turning over or moving up or down
Pitch		To control a device or object from a distant location.
Roll		To have human characteristics.
Autonomous		A robot that is operated remotely.
Robot		Device at the end of a robot arm that is used to grasp or engage objects.
Telerobotics		To rise up or dip down.
Teleoperation		Skill, flexibility, and range of mobility.
Robotics		Existing or functioning independently



Pre-Conference Requirements

Teacher's Page with suggested answers:

Answers to Pre and Post Assessment Questions

1. **Answers vary**
2. **Students draw picture**
3. **Answers vary**
4. **Articulated** – Jointed arm.

End Effector – Device at the end of a robot arm that is used to grasp or engage objects.

Degrees of Freedom – Each plane in which a robot can maneuver.

Robot – Mechanical or electromechanical device that performs human tasks, either automatically or by remote control (From the Czech word robota).

Robotics – Study and application of robot technology.

Telerobotics – Robot that is operated remotely.

Teleoperation – To control a device or object from a distant location.

Anthropomorphic – To have human characteristics.

Dexterity – Skill in using one's hands, body, or mind. Skill, flexibility, and range of mobility.

Pitch – To rise up or dip down.

Roll – To move by turning over and over. To rock back and forth.

Autonomous – existing or functioning independently.

Yaw – To move left or right without turning over or moving up or down.



Expedition Videoconference Guidelines

Audience Guidelines

Teachers, please review the following points with your students prior to the event:

- Videoconference is a two-way event. Students and NASA presenters can see and hear one another.
- Students are sometimes initially shy about responding to questions during a distance learning session. Explain to the students that this is an interactive medium and we encourage questions.
- Students should speak in a loud, clear voice. If a microphone is placed in a central location instruct the students to walk up and speak into the microphone.
- Teacher(s) should moderate students' questions and answers.

Teacher Event Checklist

Date Completed	Pre-Conference Requirements
	1. Print a copy of the module.
	2. Have the students complete the online pre-assessment.
	3. Email questions for the presenter. This will help focus the presentation on the groups' specific needs.
	4. Review the Audience Guidelines, which can be found in the previous section.
	Day of the Conference Requirements
	1. The students are encouraged to ask the NASA presenter qualifying questions about the Expedition.
	2. Follow up questions can be continued after the conference through e-mail.
	Post - Conference Requirements
	1. Have the students take the online Post-Assessment to demonstrate their knowledge of the subject.
	2. Use the provided rubric as guidelines for content and presentation criteria.
	3. Teacher(s) and students fill out the event feedback.



Expedition Videoconference Outline

Introduction to Challenge Videoconference

Robots have been a staple of our culture for the past half-century. We have all seen them in movies, on television, and in science fiction stories performing tasks that range from the mundane to the extraordinary. Because of the mental images we have of robots, sparked in great measure by the influence of science fiction, we often fail to recognize how widespread their use is in our daily lives. Everywhere we look, robots and automated systems do work for us and help make our lives more convenient if not easier. Often we do not recognize real robots because they differ from the images we have of them and from the jobs we tend to believe they do. As our society becomes more technologically dependent, however, the role of robots will increase significantly and knowing what they do and how they do it will be an important factor in many professions of the future. NASA already uses robotics technology to great extent in its exploration of space. During this Expedition, students and teachers will have an opportunity to learn firsthand about NASA's use of robots and how they are being designed and built to help humans explore the universe. Learn how NASA defines robotics, see how robotic systems are already widely used in the space program and what plans there are for future robotic applications. This interesting look into the world of space robotics will also highlight educational and professional opportunities that could be the catalyst that helps some students to identify a career path. So join us for this live, interactive learning session for a glimpse into the technologies of the 21st century happening now at NASA.

Outline for Video Conference

- I. Welcome**
- II. Introduction**
- III. History of Robots**
- IV. Today's Robots**
- V. Robotics Terms**
- VI. NASA Robots**
- VII. Careers**
- VIII. Q&A**
- IX. Good-Bye**



9-12 Activity #1

Astronauts Little Helpers Article:

In the near future, an astronaut may be awakened in the morning by a personal assistant that will provide a briefing for the coming day. There are computer files to check, experiments to monitor, inventories to update, web sites to consult, reports to file and for each task, the astronaut's assistant keeps track of progress, notes unusual circumstances, and provides feedback. The assistant also keeps a log of conditions on the Space Shuttle or Space Station. For example, if levels of oxygen, hydrogen, or emissions reach critical levels, the assistant lets everyone know. The assistant can also help when a videoconference is needed by providing the hookup and transmission requirements.

That's a mighty busy assistant! The surprising part is that this assistant isn't a human; it's a robot. To most people, however, this robot doesn't look like anything they might expect. Not at all humanoid, this robot looks like a large, red, flying grapefruit. It's packed full of sensors, miniaturized video equipment, wireless network equipment, and technology that allows the robot to understand spoken commands and reply with the same.

"We're developing an intelligent robot that essentially can serve as extra eyes, ears, and nose for the crew and ground support personnel," says Yuri Gawdiak, principal researcher for the Personal Satellite Assistant (PSA) in development at NASA's Ames Research Center in California. "The PSA will allow scientists to interact naturally with the crew. Because it's not a humanoid shape, it will offer more **dexterity** and enhanced performance because it can travel where people can't." **Prototypes** are being developed; a test flight is planned for mid-2002, and a year later, the PSA could be on the job up in space.

Developing the PSA has presented scientists with enormous challenges. PSA will operate in microgravity conditions, and it's difficult to simulate those settings here on Earth. "There will be lower power requirements up in space for the robot to move," says Gawdiak. "On the Space Station, it takes far less effort and much reduced power requirements."

The PSA is eerily close to the flying **bot** that taught Luke Skywalker to fight with a light saber in *Star Wars*. It floats in microgravity, and propels itself by using small fans. PSA maneuvers tight corners records actions on video, and can go where humans can't—to check on a potentially hazardous situation, for instance. Several PSAs could be used to locate environmental problems such as pressure leaks, temperature spikes, and gas emissions. Besides alerting astronauts to dangerous situations, the PSA can also take care of tedious tasks ranging from inventory control to monitoring experiments to taking the night **sentry** shift.

The PSA can transfer data between the spacecraft's main computers and those on the ground at mission control. PSA can receive programmed instructions and be modified as needed. PSA can serve as a video outlet for communicating between Earth and space. And because it's so personally programmable, PSA will be able to learn how each user wants to be



assisted, Gawdiak says. "PSA will learn whether you want it to fly beside you or behind you. It will learn your schedule, get you the updates you want from the ground, and interact with you on a highly personal scale. It won't just be mobile; it will understand much of what you want it to do."

The PSA serves four main functions:

1. Environmental monitoring: The PSA patrols astronaut living quarters and laboratories to monitor oxygen, nitrogen, carbon dioxide, and other gas levels. PSA can also monitor experimental data such as microgravity levels, temperature, and atmospheric pressure.
2. Communications links: PSA functions as a remote, mobile data display terminal for system and experimental data. PSA has communication input and output capabilities, including a microphone, speakers, a camera, and a display panel. These features allow for audio conferencing, videoconferencing, and a wireless relay to link other communication systems.
3. Remote operations support: Ground controllers are able to communicate with the PSA and maneuver the device into the desired location. Once in position, the PSA can use its sensors to monitor the status of experiments or to provide ground controllers with remote views of mission operations.
4. Crew worksite support: The PSA provides astronauts onsite access to information such as vehicle status and crew health data, mission schedule, inventory tracking, location information, and training support. PSA also has the ability to provide updates and alarms related to system events, payload events, or mission experiments.

"Operations we take for granted are very hard to program into a robot," Gawdiak says. "Something as basic as deciding where and when to go to a location, and how to react to variables that might come up along the way are enormously complex programs. The technology that has come about to create the PSA is directly transferable to Earth. In any system—a subway or a factory, for instance—robots can be assigned the mundane and dangerous situations, rather than humans. Managing inventory, monitoring hazards, and performing security can be done by robots to spare humans the risk."

Robotic Arm

Teacher Sheet(s)

Objective: To develop a robotic arm and an end effector to interact with the environment.

Level: 9-12

Subjects(s): Space Science, Physical Science, Technology

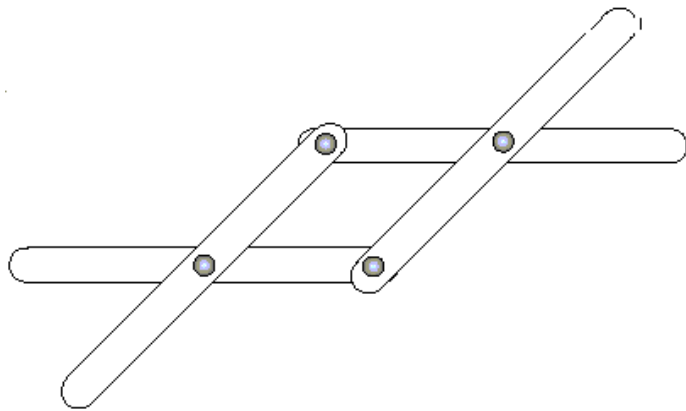
Prep Time: Less than 10 minutes

Duration: 50 minutes

Materials Category: General Classroom

Materials:

- Wooden craft sticks
- Drill
- Small brass paper fastener
- Assorted small materials



Related Links:

[Let's Talk Robotics - Video Resource Guide - EV-1998-04-015-HQ](#)

[NASA Rover Ranch](#)

Supporting Article(s):

Astronauts' Little Helpers

Pre-Lesson Instructions:

Optional: Order a copy of the NASA video "Let's Talk Robotics" from [NASA CORE](#)

Video Synopsis

Length/Year	14 minutes/1998
Format	1/2" VHS
Item Number	011.0-04V
Price	\$10.00

Description:

This video program examines some of NASA's robotic research and how robots are used in space exploration. In this video, several of NASA's robotic applications are explored. Viewers will learn about the Pathfinder robot that landed on Mars in 1997 and released a microrover spacecraft (Sojourner) to explore the nearby Marscape. Viewers will also learn about the 15 meter-long Remote Manipulator System arm that Space Shuttle astronauts use to handle payloads in space and to assist in space construction and satellite repair operations. Research being done to test robotic arms for the International Space Station and a free-flying camera robot will also be seen.

Note: This lesson can be completed with or without the video. The video is a great introduction to the topic of robotics.

Background Information:

None

Guidelines:

1. Read the 9-12 article, "Astronauts' Little Helpers." Discuss the use of robotics in movies and in everyday life.
2. Provide time for students to brainstorm and modify their robotic arms.
3. Each student or group of students will need a minimum of four craft sticks and four brass fasteners.

Discussion/Wrap-up:

None

Extensions:

- Complete Lesson 2 under 9-12 article, "Astronauts' Little Helpers."
- Explore K-12 Experiments in Robotic Software at the [NASA Rover Ranch](#).

Robotic Arm

Student Sheet(s)

Materials

- Wooden craft sticks
- Drill
- Small brass paper fastener
- Assorted small materials

Background Information

The word robot comes from the Czech word robota that means forced or repetitive labor. Czech playwright Karel Capek coined the term for his 1920 play R.U.R. (Rossum's Universal Robots). In the play, the human-like robots take over the world.

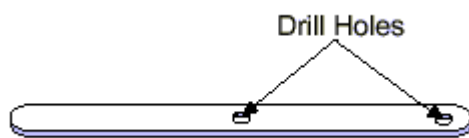
Today's robots usually look very different from humans. They are found in manufacturing, research, medical treatment, entertainment, and space. NASA uses robots to explore Earth and the other planets and to manipulate payloads on the Space Shuttle, and plans to use several robotic arms on the International Space Station.

The definition of what a robot is varies with the source referenced. Generally, robots are machines that operate by computer controls. On Earth, robots are often used for dangerous, dirty, or dull jobs. Examples include painting and welding robots in automotive assembly lines and robots used to dismantle old nuclear power plants. In NASA-sponsored experiments, walking robots were used to explore active volcanoes in Alaska and the Antarctic.

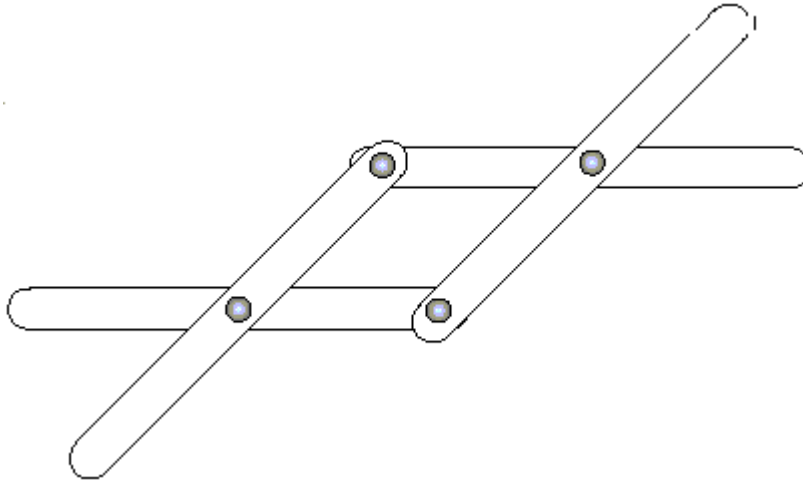
One of the important objectives in the development of robots is to enable robots to interact with their environment. Interaction is often accomplished with some sort of arm and gripping device or end effector.

Procedure

1. Define the following terms:
 - Articulated
 - End effector
 - Telerobotics
2. Drill holes through the craft sticks as shown in the diagram.



3. Each student will need four drilled sticks and four brass paper fasteners. Note: dampening the sticks before drilling can reduce cracking the wood.
4. Assemble robotic arms as shown in the illustration below.



5. Try to pick up a pencil or some other object with the arm.
6. Next, design some sort of end effector for the end of the arm that will enable you to pick up different objects.
7. Attach the effector to the ends of the arm with glue.
8. Write a paragraph evaluating your design by picking up different objects.
9. Would the arm and end effector have to be modified to pick up sediment and pebbles on Mars?



9-12 Activity #2

Supporting Article: Astronauts' Little Helper

Robotic Maze

Teacher Sheet(s)

Objective: To develop a robotic arm and an end effector to interact with the environment.

Level: 9-12

Subjects(s): Space Science, Physical Science, Technology

Prep Time: Less than 10 minutes

Duration: Two 50-minute class periods

Materials Category: Special Requirements

Materials:

- Battery-operated toy car
- Masking tape
- Assortment of materials to build a robotic arm
- Assorted small materials to pick up with the robotic arm

Related Links:

[Let's Talk Robotics - Video Resource Guide - EV-1998-04-015-HQ](#)

[NASA Rover Ranch](#)

Supporting Article(s):

Astronauts' Little Helpers

Pre-Lesson Instructions:

- Optional: Order a copy of the NASA video "Let's Talk Robotics" from [NASA CORE](#).
- Purchase enough battery-operated toy cars for each group of four to have one.

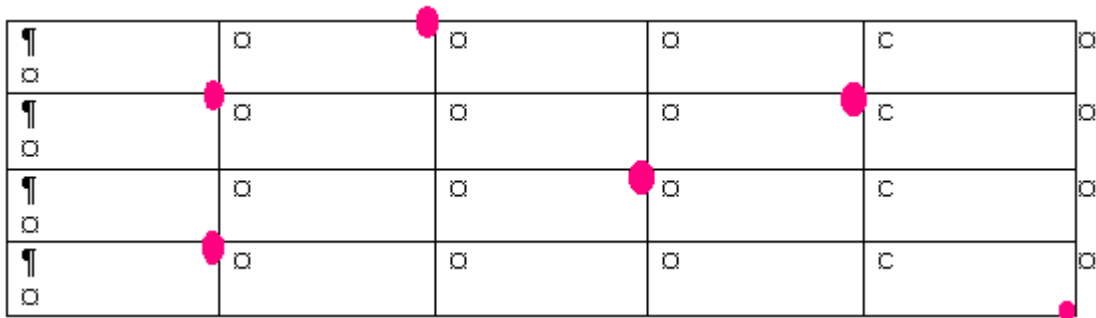
- Introduce the lesson a week prior to building the robotic vehicles. Have students brainstorm how they could build the robotic arm, and have students bring materials for their robotic arms to school.
- Choose a large area to map out the maze.

Background Information:

None

Guidelines:

1. Read the 9-12 article, "Astronauts' Little Helpers." Discuss the use of robotics in movies and in everyday life.
2. Provide time for students to brainstorm and modify their robotic arm.
3. Using masking tape, construct a gridline box on the floor based on the following pattern:



4. Place a small object at each circle in the grid the robotic vehicle must pick up.
5. Each team's robotic vehicle must travel only on the gridlines. If a vehicle strays off a gridline, there is a 5-second penalty.
6. Have students graph the number of successful retrievals, and note the time for each.

Discussion/Wrap-up:

None

Extensions:

- Complete Lesson 1 under 9-12 article, "Astronauts' Little Helpers."
- Explore K-12 Experiments in Robotic Software at the [NASA Rover Ranch](#).
- Have students design or build their own rovers, explaining what type of instrumentation

they would include and why it is necessary.

- Have students research the history of robotics and create a time line on the wall of the advancements of robots.

Robotic Maze

Student Sheet(s)

Materials

- Battery-operated toy car
- Masking tape
- Assortment of materials to build a robotic arm

Background

By definition, a robot is an electronically controlled device programmed to conduct a series of jobs. The physical appearance of the robot is generally the result of the functions they have been built to perform. Like computers, robots follow commands. Without proper programming, robots can not complete the task at hand.

Procedure

1. Each team will be provided a battery-operated toy car. Each team's goal is to build an arm for the vehicle. A gridline maze will be constructed on the floor. After construction of the robotic arm vehicles, each team will compete to complete and pick up the items in the maze. The team with the most items retrieved in the shortest time is the WINNER.
2. Examine the toy car. Practice operating the remote controlled car, steering the car to the left and right in order to turn corners and reversing the direction of the car. Your car must stay on the gridlines of the maze. Each time the car is off the taped gridline, a 5-second penalty is added to your final score time.
3. Brainstorm as a group about the materials needed to build a robotic arm to attach to the car.
4. Bring in materials. Build and attach the arm to the car. Practice again before the big competition.
5. For the competition, make a data table of each team's number of items retrieved and the total completion time in seconds.

Conclusion

After the competition, re-evaluate the design of your car. Would you do any modifications? Explain.

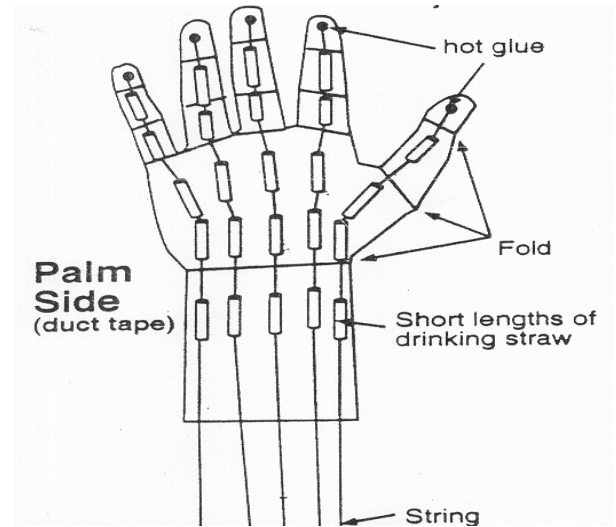


9-12 Activity #3

Robot Hand (End Effector)

Materials

- Styrofoam Food Tray (one per student)
- Marker Pens
- Duct Tape
- Scissors
- Glue
- Straws (one per student)
- String (two large rolls)
- Rubber Bands (approx. 3 per student)
- Paint Stick (one per student)
- *Robot Hand (End Effector)* handout (one per student)



Robots are often used to assist humans. In this activity, students will create an end effector designed to replicate the human hand.

1. Remind the students what an end effector is.
2. Announce that they will be creating a rather complex end effector.
3. Pass out the *Robot Hand (End Effector)* handout.
4. Allow the remainder of class for the students to complete the activity.

3) Write a set of directions on how to move your arm from your side to scratch your nose. This will be a set of program directions similar to those written by engineers working to design a robotic system for movement to complete a task.

4) Match the following terms with their correct definitions:

Articulated		A mechanical or electromechanical device that performs human tasks, automatically or by remote control.
End Effector		The study and application of robot technology.
Degrees of Freedom		Each plane in which a robot can maneuver.
Anthropomorphic		To move by turning over and over. To rock back and forth.
Dexterity		Jointed arm.
Yaw		To move left or right with out turning over or moving up or down
Pitch		To control a device or object from a distant location.
Roll		To have human characteristics.
Autonomous		A robot that is operated remotely.
Robot		Device at the end of a robot arm that is used to grasp or engage objects.
Telerobotics		To rise up or dip down.
Teleoperation		Skill, flexibility, and range of mobility.
Robotics		Existing or functioning independently



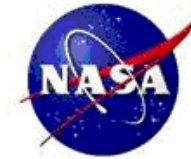
NASA Education Evaluation Information System (NEEIS)

Please complete an online evaluation form to provide feedback on the NASA Expedition.

Feedback from you and a few of your students would be appreciated.

<http://dl.nasa.gov/dln/content/feedback/>

National Aeronautics and Space Administration



NASA Digital Learning Network

presents

Certificate of Completion

to

for

Spacebots

Instructor

Date



Vocabulary

Articulated – Jointed arm.

End Effector – Device at the end of a robot arm that is used to grasp or engage objects

Degrees of Freedom – Each plane in which a robot can maneuver.

Robot – Mechanical or electromechanical device that performs human tasks, either automatically or by remote control (From the Czech word robota).

Robotics – Study and application of robot technology.

Telerobotics – Robot that is operated remotely.

Teleoperation – To control a device or object from a distant location.

Anthropomorphic – To have human characteristics.

Dexterity – Skill in using one's hands, body, or mind. Skill, flexibility, and range of mobility.

Pitch – To rise up or dip down.

Roll – To move by turning over and over. To rock back and forth.

Autonomous – existing or functioning independently.

Yaw – To move left or right without turning over or moving up or down.



Resources

Robotics Education Project - The NASA Robotics Education Project (RE) is dedicated to encouraging people to become involved in science and engineering, particularly building robots. Visit this website to learn about robotics competitions and how to get involved.

<http://robotics.nasa.gov/>

NASA Space Telerobotics Program - This program is an element of NASA's ongoing research program, under the responsibility of the Office of Space Science. The program is designed to develop telerobotic capabilities for remote mobility and manipulation, by merging robotics and teleoperations and creating new telerobotics technologies. http://ranier.hq.nasa.gov/telerobotics_page/telerobotics.shtm

A great NASA site for **robotic rover technology research** being conducted at the Jet Propulsion Lab in California.

<http://www-robotics.jpl.nasa.gov/videos/index.cfm>



Background Information

Robotics Competitions

<http://robotics.nasa.gov/students/challenge.php>

Ask a Robotocist.

<http://robotics.nasa.gov/students/robotics.php>

Phoenix Mars Mission: Just for Kids

<http://phoenix.lpl.arizona.edu/kids.php>

Mosaic Robot Puzzle

http://spaceplace.nasa.gov/en/kids/robots/robot_puzzle.shtml



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**Museum of Flight
Johnson Space Center**

Special Thanks to the following organizations and people:

JSC Robotics